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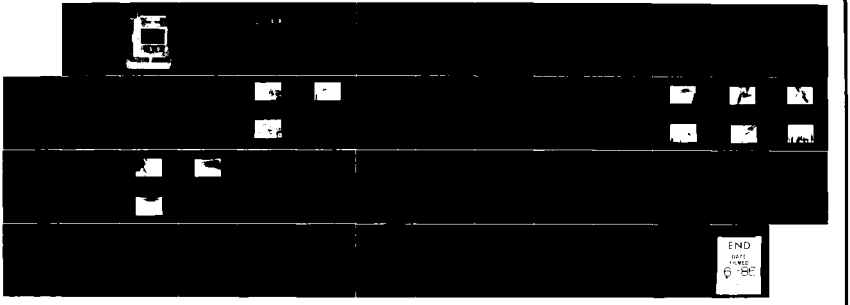

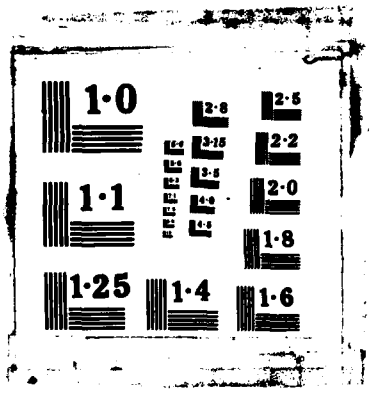
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DAMAGE ASSESSMENT REPORT
PIER 4
NAVAL WEAPONS STATION
CONCORD, CA

FPO-1-82-(28) OCTOBER 1982

PERFORMED FOR:
OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C. 20374

UNDER:
CONTRACT N62477-81-C-0448
TASK 5

BY:
CHILDS ENGINEERING CORPORATION
MEDFIELD, MASSACHUSETTS 02052

Unclassified
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11. TITLE (Including Security Classification)
Underwater Facilities Inspections & Assessments at Damage Assessment Report
Pier 4 Naval Weapons Station Concord, CA

12. PERSONAL AUTHOR(S)

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17. COSATI CODES FIELD GROUP SUB-GROUP	18. SUBJECT TERMS (Continue on reverse if nec.) Underwater inspection, Mooring inspection, Naval Weapons Station Concord, CA

19. ABSTRACT (Continue on reverse if necessary & identify by block number)
The inspection of Pier 4 was performed at the request of the Naval Weapons Station, Concord, California. The pier was damaged when it was impacted by a departing vessel. It is reported that the stern of the vessel struck the pier at approximately Bent 120.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT SAME AS RPT.	21. ABSTRACT SECURITY CLASSIFICATION
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SECTION 1.0 INTRODUCTION

This report is a product of the Underwater Inspection Program conducted by the Ocean Engineering and Construction Project Office (FPO-1), Chesapeake Division, Naval Facilities Engineering Command (NAVFACENGCOM) under NAVFAC's Specialized Inspection Program.

This program sponsors task-oriented engineering services for the inspection, analysis and design, and monitoring of repairs for the submerged portions of selected Naval Waterfront Facilities. All services required to produce this report were provided by Childs Engineering Corporation of Medfield, Massachusetts under Task No. 5.0 of Contract No. N62477-81-C-0448.

The inspection of Pier 4 was performed at the request of the Naval Weapons Station, Concord, California. The pier was damaged when it was impacted by a departing vessel. It is reported that the stern of the vessel struck the pier at approximately Bent 120.

1.1 REPORT CONTENT

The report contains a description of inspection procedures, the results of the inspection and analysis of the findings, accompanied by pertinent drawings and photographs. Specifically, the inspection results include a description of inspection procedures, the observed condition and a structural assessment of that condition. Recommendations for the facility, including cost estimates (based on present local prices) for any repair work, are also included. Structural assessment calculations and cost estimate breakdowns can be found in the Appendix.

SECTION 2.0 INSPECTION PROCEDURE

Between October 18 and October 20, 1982, a CHESNAVFACENGCOM engineer, accompanied by a three-person Engineer/Diver inspection team from Childs Engineering, performed an on-site underwater inspection of the damaged section of Pier 4, Naval Weapons Station in Concord, California. The level of inspection to be performed, the type of structure being inspected, actual on-site conditions and past experience, combined with a thorough knowledge of engineering theory, dictated the inspection procedures that were followed.

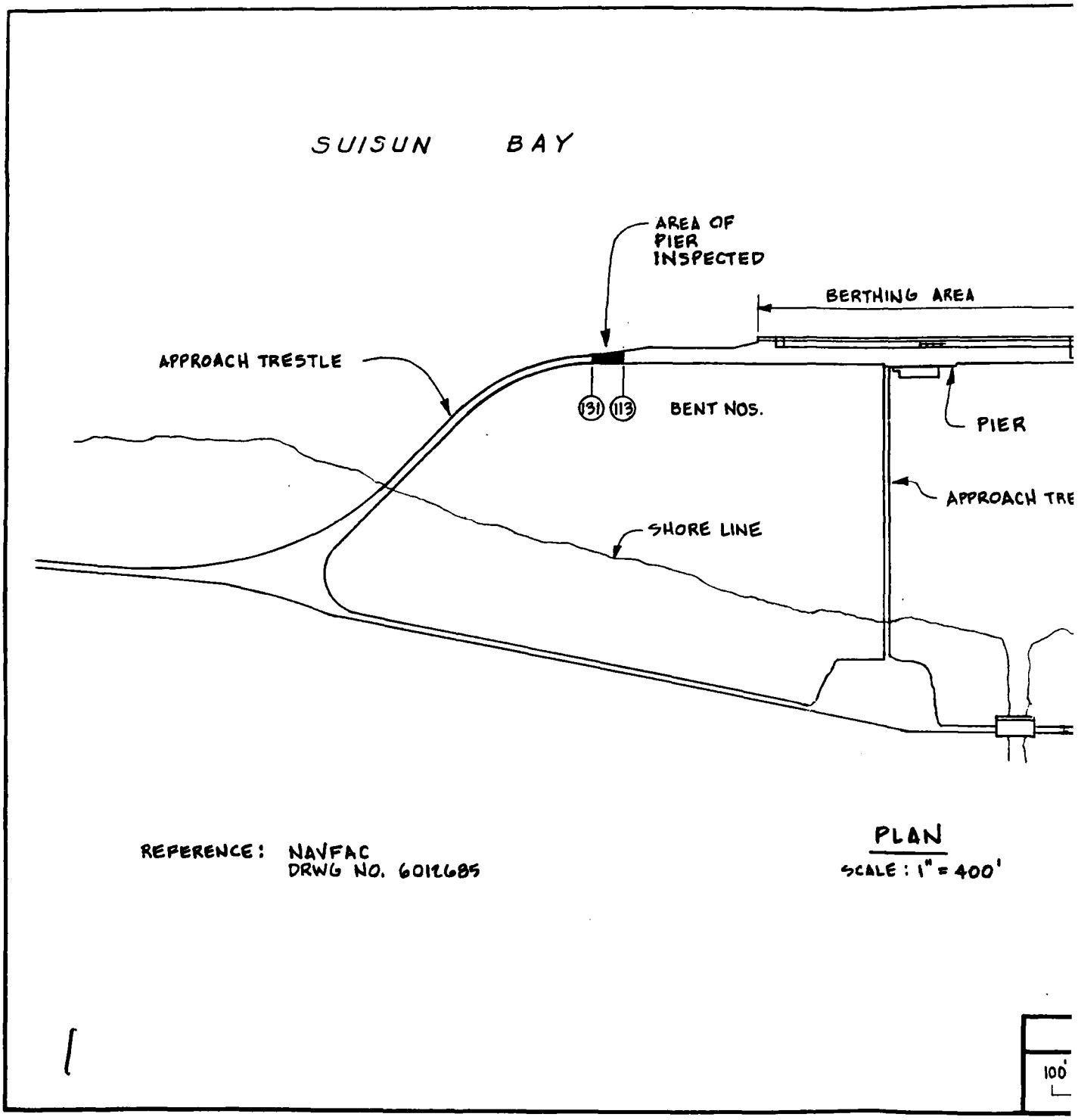
2.1 LEVEL OF INSPECTION

The inspection techniques used had to be sufficient to yield information necessary to make a general condition assessment of the supporting structure of the facility, identify any areas that were mechanically damaged or in advanced states of deterioration and formulate repair and maintenance recommendations with cost estimates. In general, this means utilizing visual/tactile inspection techniques. Photographic documentation of typical as well as unusual conditions was also obtained.

2.2 INSPECTION PROCEDURE

A dive team consisting of two divers and a tender performed the on-site inspection. Each pile in the damaged section of the pier (see Figure 1) was inspected for its full exposed length. Since visibility under water was less than 3", the piles were examined utilizing tactile techniques.

It should be noted that in general, non-destructive methods of inspection were employed. The conditions noted reflect direct observation of structural components. Information which may infer knowledge of conditions not accessible by non-destructive



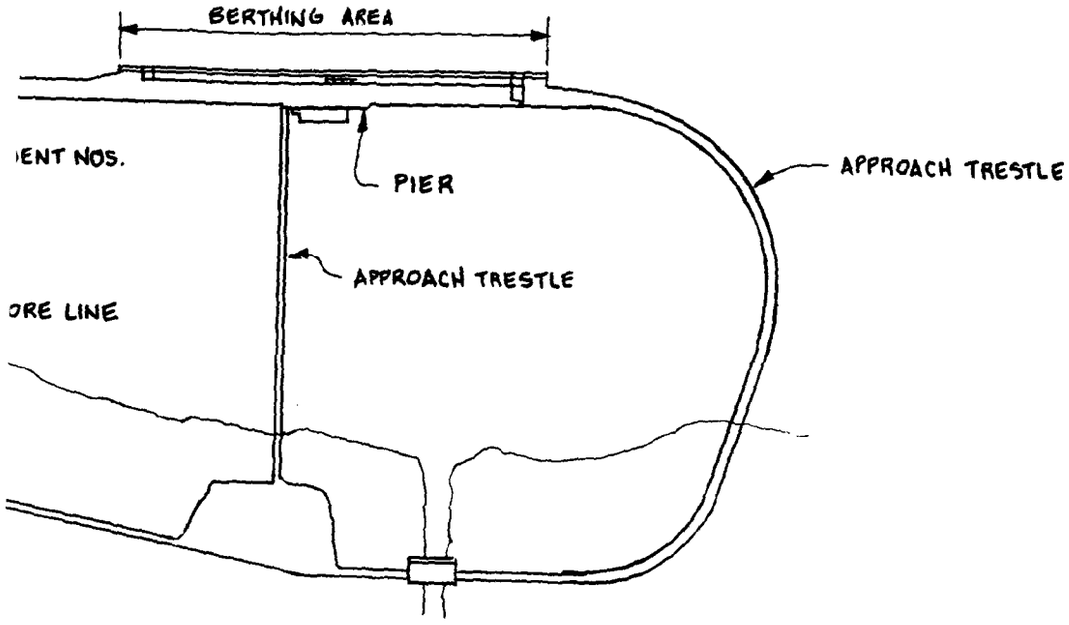
REFERENCE: NAVFAC
DRWG NO. 6012685

PLAN

SCALE: 1" = 400'

100'

EA OF
R
SPECTED



PLAN

SCALE : 1" = 400'

2

GRAPHIC SCALE			
100' 0 100' 400' 700'	CHILDS ENGINEERING CORPORATION BOX 253 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
		NAVAL WEAPONS STATION CONCORD, CA	FIG NO
		PIER PLAN	1

testing methods is based on government-furnished documents, our knowledge of structures in similar environments and/or generally accepted engineering theories.

Several core samples were taken in two of the damaged piles. The samples were taken to assess the condition of the timber, presence of marine borers and condition of preservative treatment.

2.3 INSPECTION EQUIPMENT

Equipment used for the inspection included a Minolta SRT 200 camera with 28mm and 200mm lenses and strobe, pneumatic coring machine, dive lights, 100-foot sounding tape, 200-foot fiberglass tape, 6-foot folding rules, chipping hammers and dive knives.

Choice of equipment was made as a result of past experience. Most of the equipment is straightforward, easy to implement, and has proven reliable under hard use.

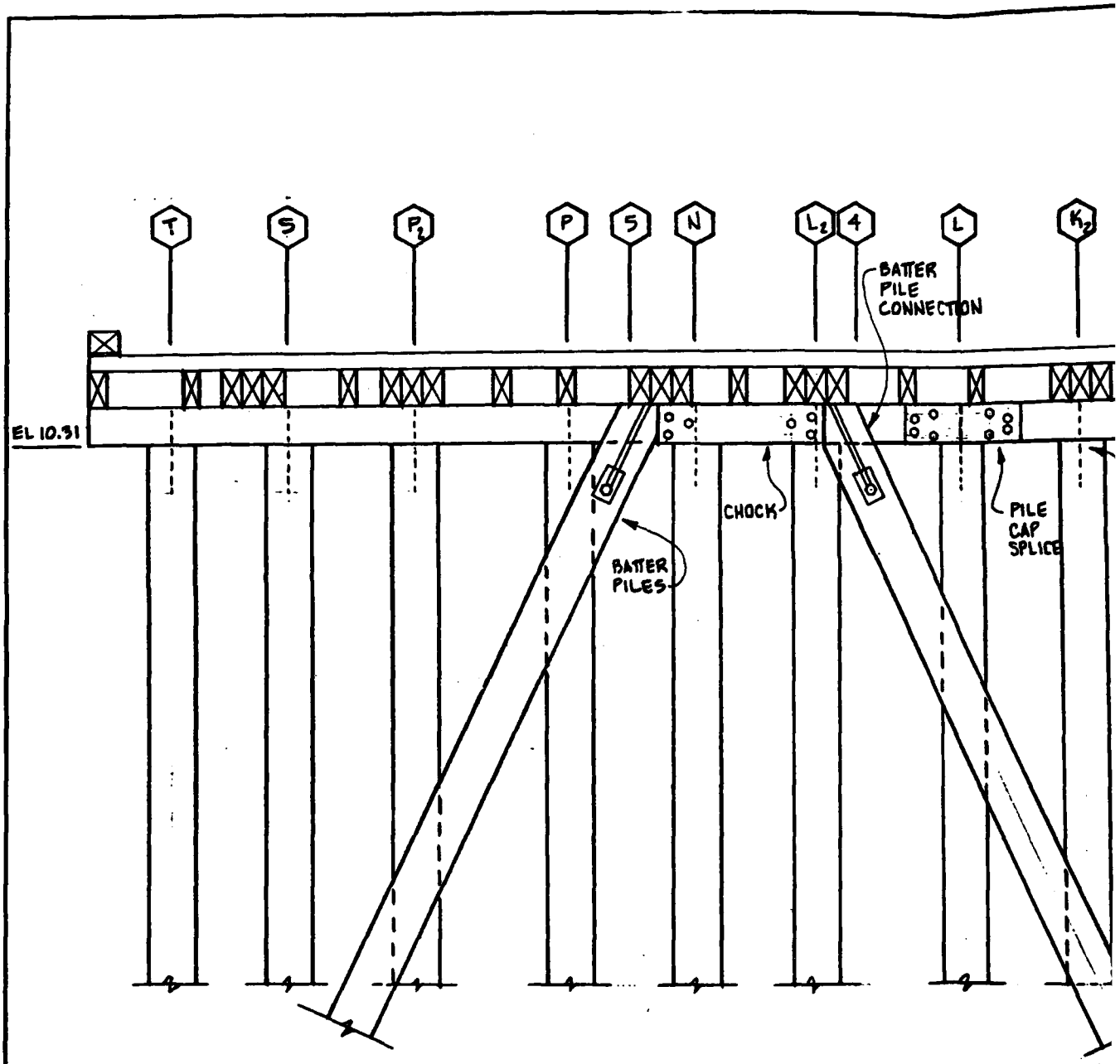
SECTION 3.0 FACILITY INSPECTION

3.1 DESCRIPTION

Pier 4 is an ordnance transfer pier located within the Naval Weapons Station Complex.

The pier was constructed in 1946 and extended in 1973. The original pier section is of timber construction with treated timber piles supporting treated timber pile caps, stringers and decking (see Figure 2).

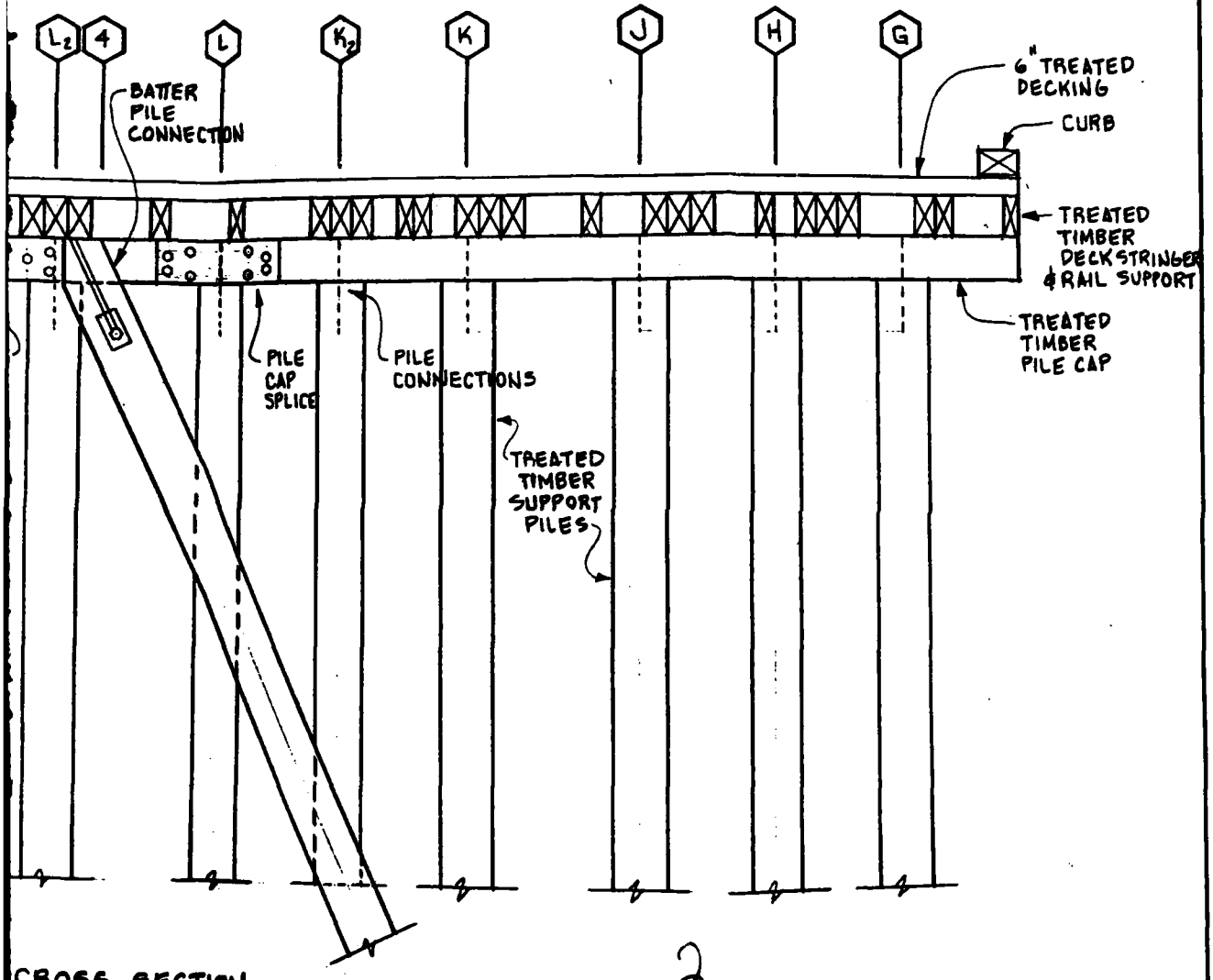
The new section of the pier is of reinforced concrete construction with precast concrete piles supporting a reinforced concrete deck. This inspection was limited to Bents 113 through 131 (see Figure 1), which were damaged as the result of a recent collision. The damaged portion of the pier is of the older timber construction.



TYPICAL CROSS SECTION

SCALE: 1/4"=1'-0"

REFERENCES: Y&D DWG. NOS. 373337 & 373338.



CROSS SECTION

E: 1/4" = 1'-0"

2

GRAPHIC SCALE	CHILDS ENGINEERING CORPORATION BOX 888 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.
1' 0 1' 2' 3' 4' 5' 6' 7'		NAVAL WEAPONS STATION CONCORD, CA — TYPICAL CONSTRUCTION — FIG. NO. 2

3.2 OBSERVED INSPECTION CONDITION

Several elements of the pier have been damaged as a result of the recent collision. Figure 3 is a summary illustration of the damage conditions. Specific structural anomalies are discussed below.

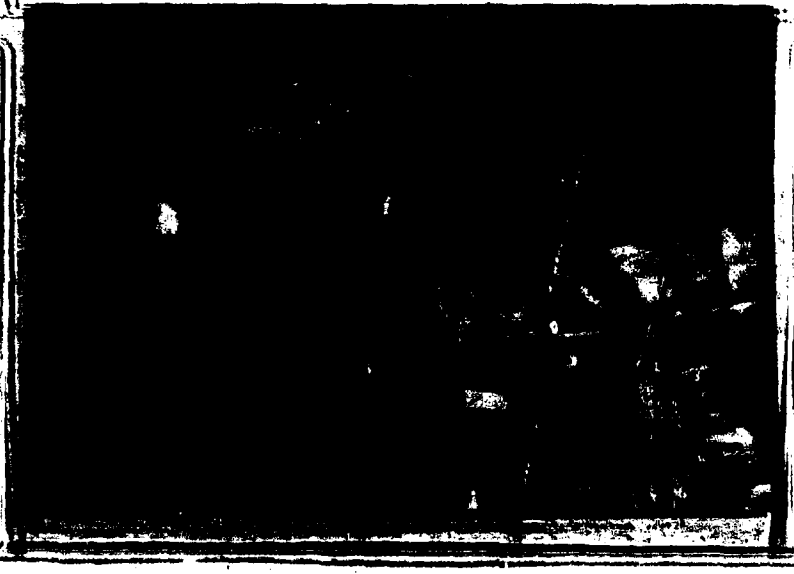
As a result of the collision, the pier between Bents 116 and 124 has a permanent deflection to the south. The maximum deflection appears to be at Bent 120 and is approximately 12" from original position. The displacement is illustrated in several ways. At the pile to pile cap connection of the vertical piles, there is a distinct rotation of the pile head. This rotation has resulted in a loss of bearing between the pile and pile cap. Typically, the pile head is bearing at the north side and there is a 1/16" to 3/8" gap at the south side (see Figure 4 and Photo 1).

At the mudline the piles have also displaced. This is illustrated by a mounding of displaced soil on the south side and a furrow where soil is settled on the north side (see Figure 5). The pile displacement at the mudline appears permanent since the soil has re-formed around the pile.

In addition to the pile head rotation, many of the piles are displaced along the length of the pile cap. This displacement is the result of fastener bending (drift pin) or local failure of the pile head timber or pile cap timber (see Figure 4 and Photo 2). In cases where the fasteners have bent, there is no noticable damage to the pile head or pile cap. Where the fasteners remain straight, either the pile cap or pile head timber, or both, have failed locally. Pile cap failure usually is illustrated by a vertical split through the pile cap which has allowed the fastener to slide. Pile head failure is illustrated by a splitting of the pile head (see Photo #3) which has

Photo #1: Pile S Bent 118. Typical pile head rotation at pile cap.

Photo #2: Pile J Bent 118. Typical pile head displacement at pile cap.



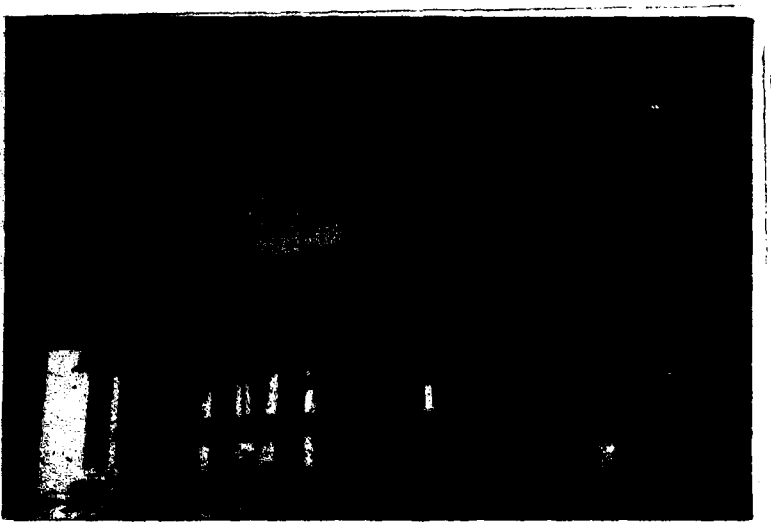
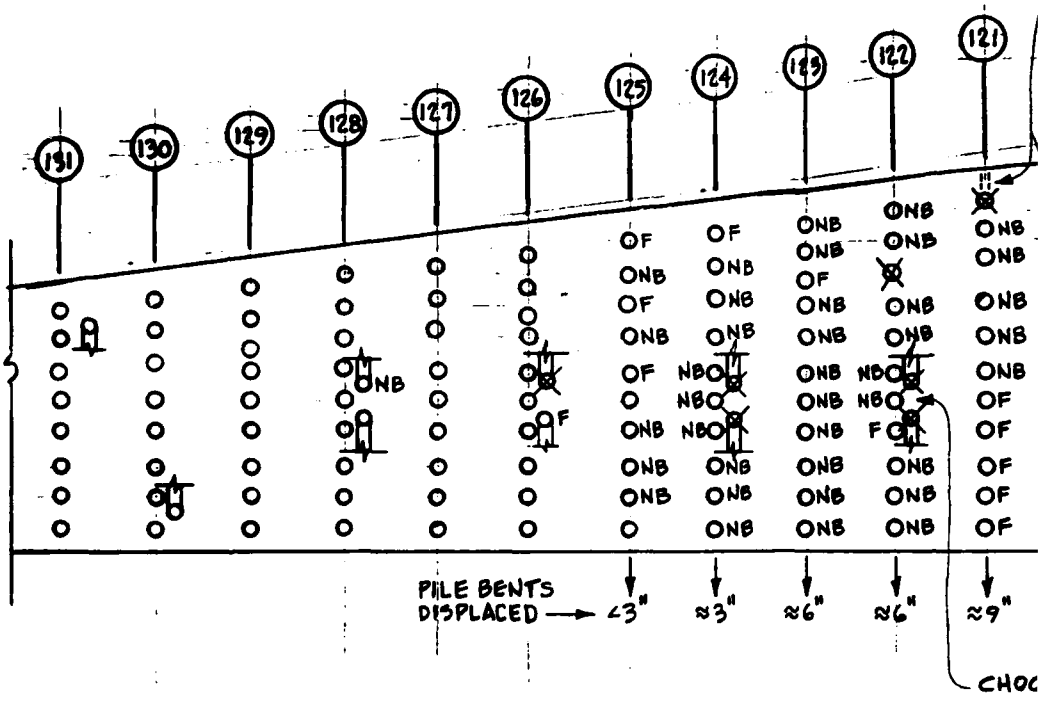


Photo #3: Pile L_2 Bent 121. Chock in pile head.



PLAN

SCALE AS SHOWN

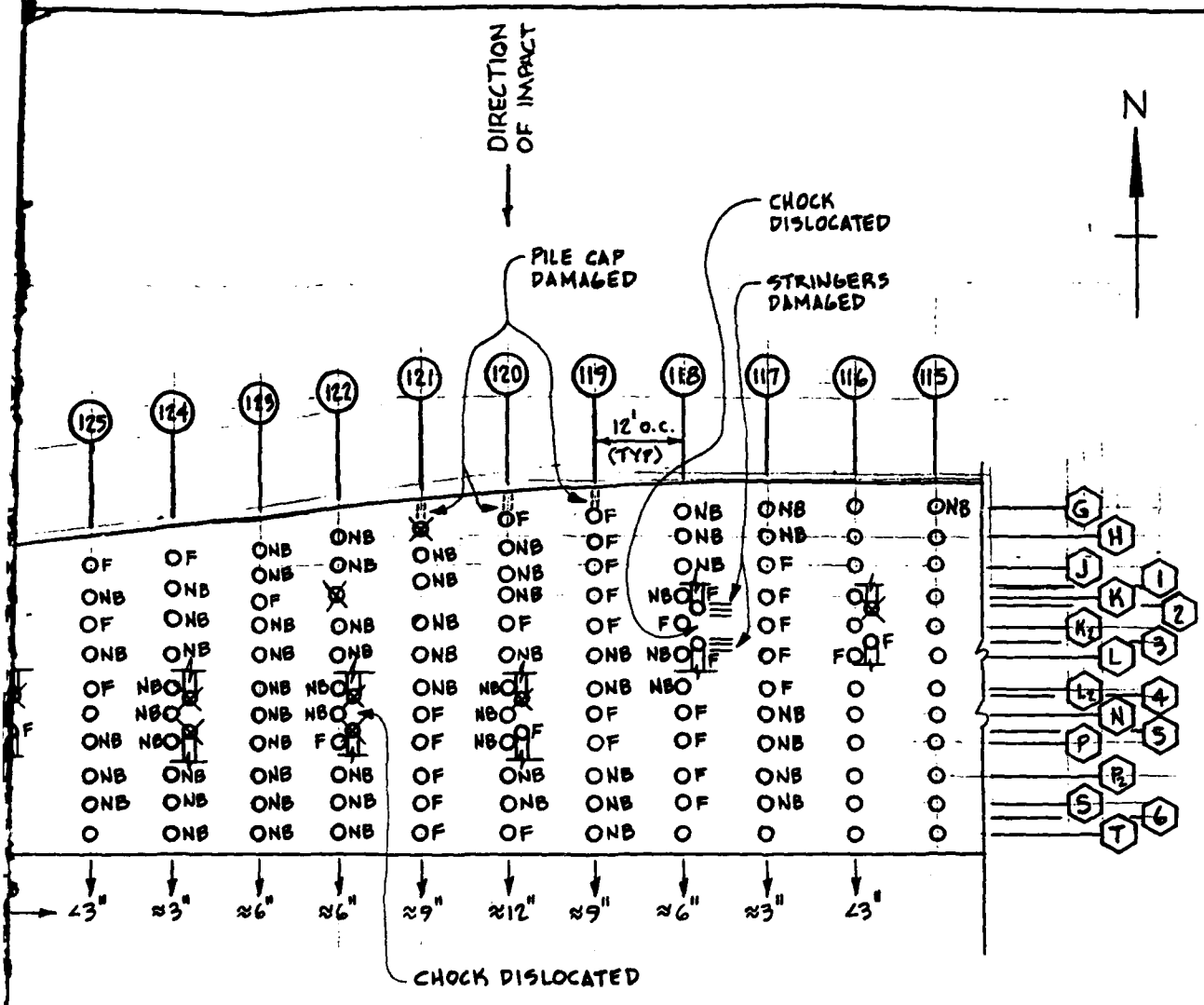
REFERENCE: PILE PLAN
Y&D DWG NO. 375337.

LEGEND

NB – PILE NOT BEARING FULLY AT PILE CAP

⊗ – PILE WITH SEVERE DAMAGE OR MISSING

F – PILE FASTENING DAMAGED OR PILE DISPLACED



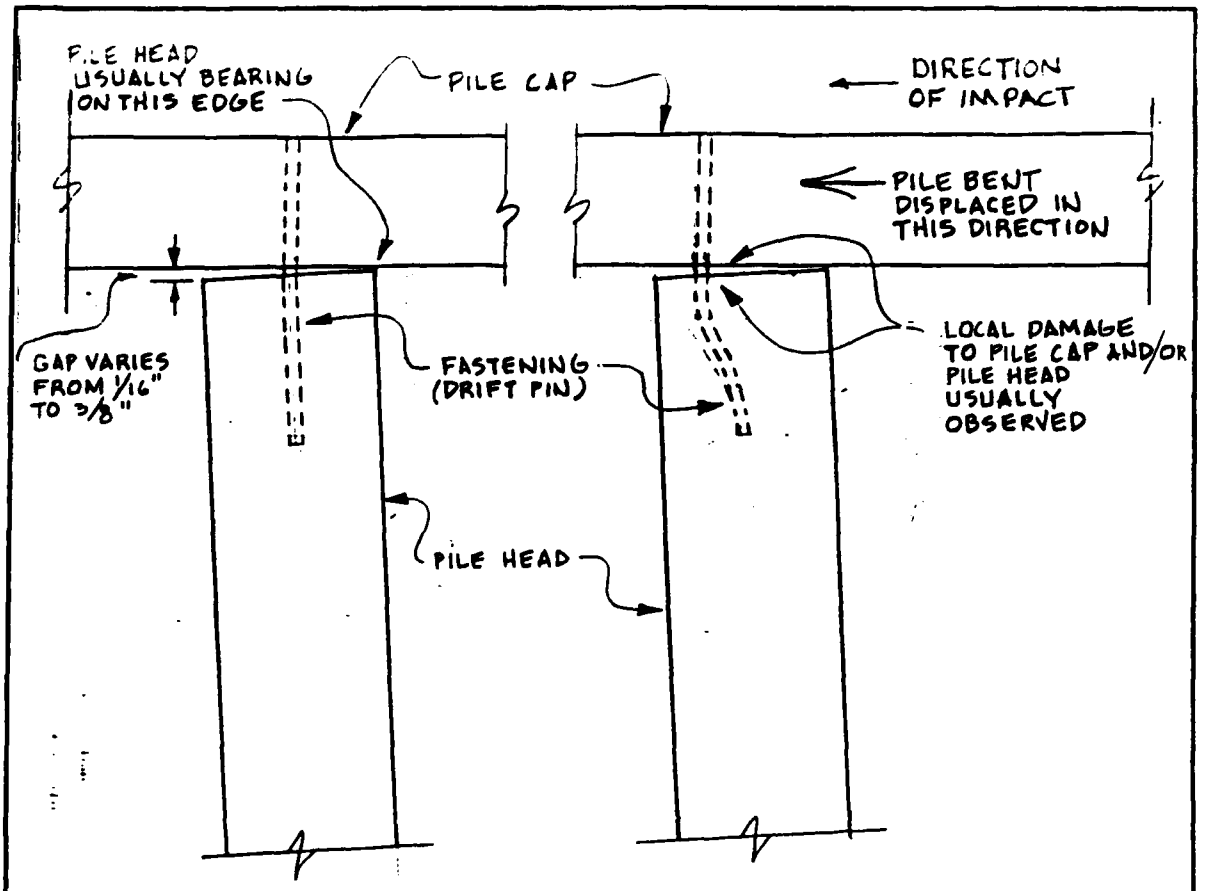
PLAN

SCALE AS SHOWN

T BEARING FULLY AT PILE CAP
TH SEVERE DAMAGE OR MISSING
STENING DAMAGED OR PILE DISPLACED

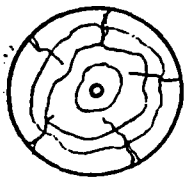
2

GRAPHIC SCALE	CHILDS ENGINEERING CORPORATION BOX 833 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.
10' 0 10' 20' 30'		NAVAL WEAPONS STATION CONCORD, CA — EXISTING CONDITIONS — FIG. NO. 3

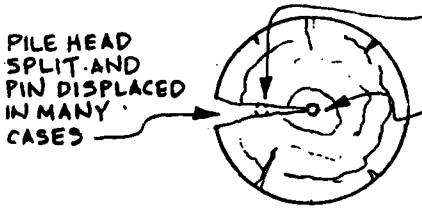


TYPICAL PILE HEAD ROTATION

TYPICAL PILE HEAD ROTATION & DISPLACEMENT



SECTION



SECTION

SCALE: 3" = 1'-0"

GRAPHIC SCALE

1' 0 1' 2'

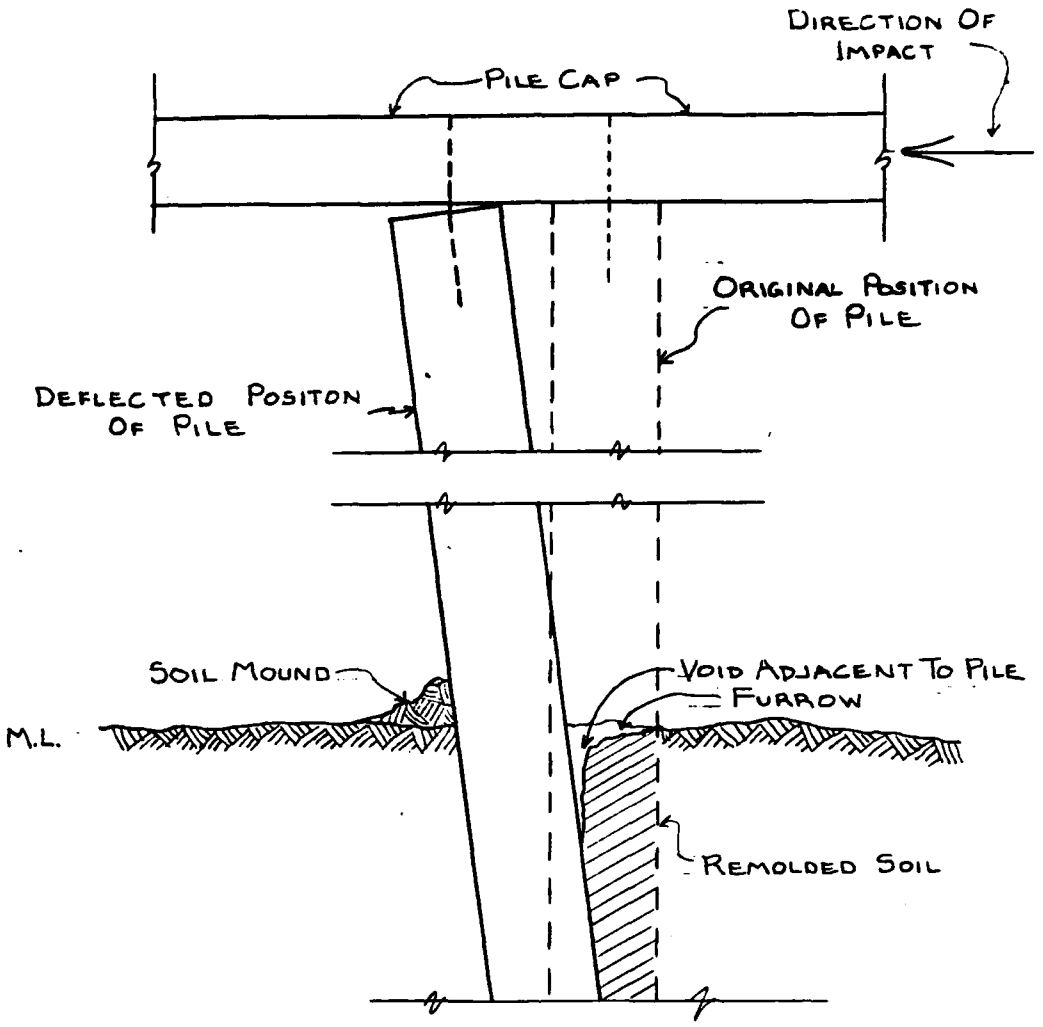
CHILDS ENGINEERING CORPORATION
BOX 331
MEDFIELD, MA

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D C

NAVAL WEAPONS STATION CONCORD, CA

PILE CONDITION

FIG NO. 4



TYPICAL PILE DISPLACEMENT

NOT TO SCALE

GRAPHIC SCALE	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.
N/A		NAVAL WEAPONS STATION CONCORD, CA — PILE CONDITION — FIG.NO. 5

Charrette 10347

allowed the pile head to displace. In one instance, Pile G, Bent 124, the pile is dislocated completely from the drift pin (see Photo 4).

In two instances, Pile K Bent 122 and Pile H Bent 121, the entire pile was damaged. Pile K Bent 122 splintered at the mudline rather than displacing the soil and Pile H Bent 121 was snapped off at the mudline and broke out from the fastening at the pile cap. It appears that Pile H Bent 121 took almost a direct hit from the vessel which explains its complete displacement.

The batter piles in some instances have been displaced also. Two of the batter piles exhibit compression failure at the mudline, Pile 5 Bent 124 and Pile 5 Bent 122. Many of the batter piles which were put in tension, have split at the pile head above the connection (see Figure 6 and Photo 5). The batter piles which have split at the heads are Pile 2 Bent 116, Pile 4 Bents 120, 122, 124 and 126.

In general, the compression batter piles have crushed into the stringers at the connection (see Figure 6 and Photo 6).

At Bent 118, both batter piles are sound but the associated chock and deck stringers are damaged (see Figure 6 and Photos 7 and 8). The chock has rotated and the stringers over the compression batter pile are severely crushed while the stringers over the tension batter pile have been torn apart.

At each batter pile there is a corresponding vertical pile with a tension connection. Two of the vertical piles, Bent 122 Pile P and Bent 116 Pile L, are split above the connection as a result of the uplift forces generated during the impact (see Photo 9).

Photo #4: Pile G Bent 124. Pile head dislocated from fastener.

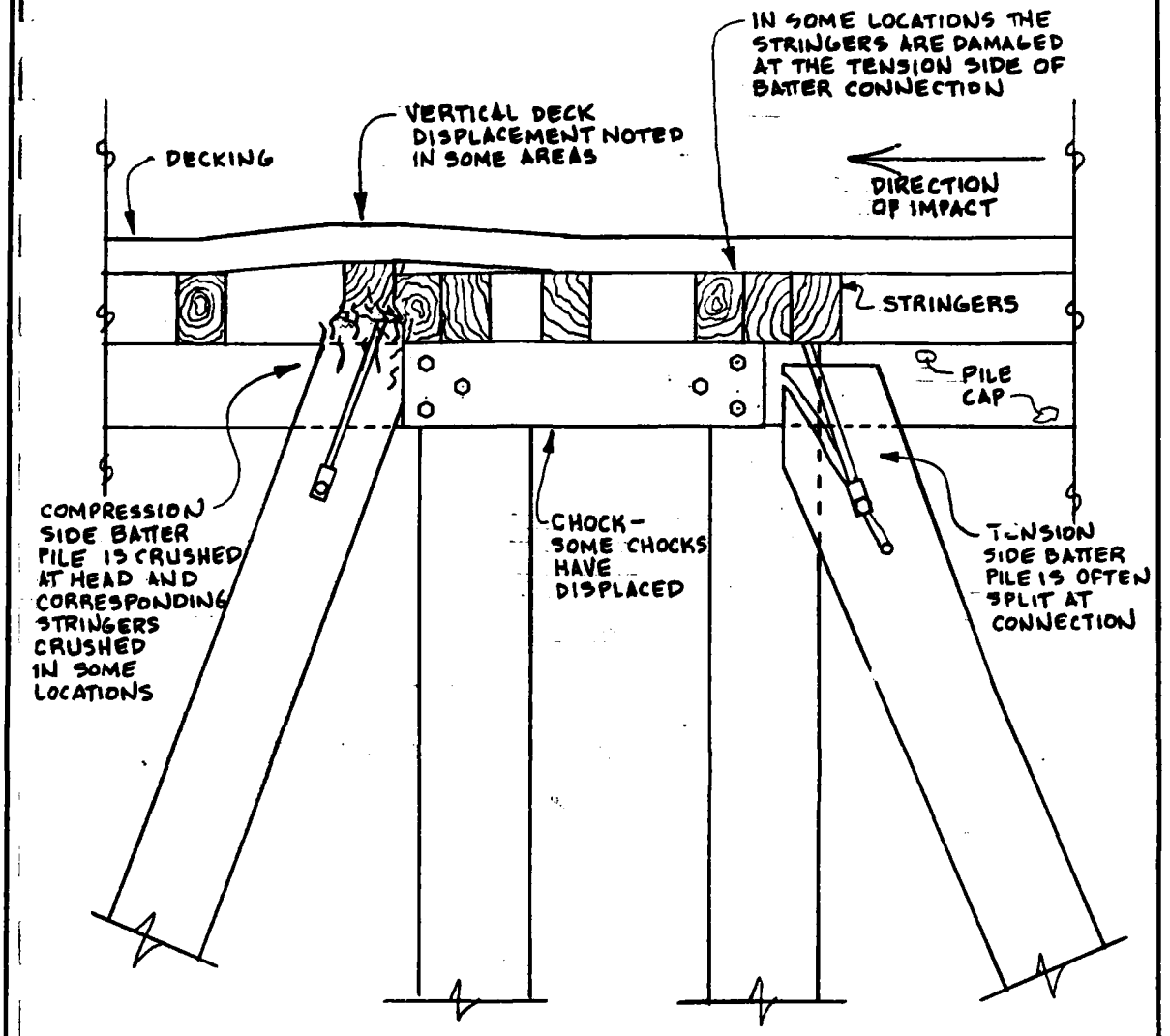
Photo #5: Pile 2 Bent 120. Typical tension failure at batter pile connection.

Photo #6: Pile 1 Bent 124. Typical compression side batter pile dislocation and crushing.

Photo #7: Pile 1 Bent 118. Severe damage to stringers at compression batter connection.

Photo #8: Pile 2 Bent 118. Severe damage to stringer at tension batter pile connection.

Photo #9: Pile K_2 Bent 116. Typical pile head failure in vertical pile with tension connection.



DAMAGE AT BATTER PILE CONNECTION

NOT TO SCALE

GRAPHIC SCALE	CHILDS ENGINEERING CORPORATION BOX 829 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.
N/A		NAVAL WEAPONS STATION CONCORD, CA — PILE CONDITIONS — FIG. NO 6

The north end of the pile caps at Bents 119, 120 and 121 have suffered varying degrees of damage. The worst condition is the splitting off of approximately 4 feet of cap timber at Bent 120 with moderate splitting and crushing of the other two cap ends. In this same area several stringers and their associated decking have been destroyed (see Photos 10, 11 and 12).

Core samples taken at several locations on two of the damaged piles indicated that the timber is still in excellent condition and the treatment is still present.

No evidence of marine borer attack was noted. This could reasonably be expected since the water is almost fresh.

Photo #10: North side Bent 120. Damage to pile cap at vessel impact area.

Photo #11: Condition of north side of pier topside at vessel impact location.

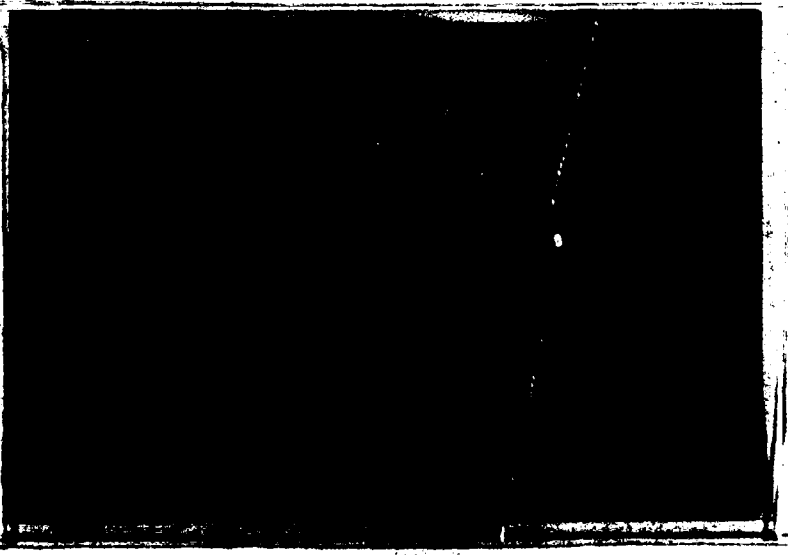


Photo #12: Vessel impact area, overview.

3.3 STRUCTURAL CONDITION ASSESSMENT

Piles which have a permanent deflection in excess of 3" at the head are no longer capable of supporting the design vertical loads without modification. Calculations indicate the imposed bending stress where permanent deflection exceeds 3" plus the vertical loads will yield an excessive combined stress. The vertical piles in Bents 117 through 124 must be replaced or end conditions modified, such that the design loads will not cause excessive stressing (see calculations in Appendix). The two vertical piles which are broken, Pile H Bent 121 and Pile K Bent 122 are not capable of handling any loads.

The two batter piles, Pile 5 Bent 122 and Pile 5 Bent 124, which have failed in compression, are no longer capable of handling any loads.

The batter piles which have split at the heads as a result of excessive tension are still functional as compression batter piles but no longer offer tension resistance. If the tension connections were relocated, these piles would again be satisfactory.

All piles which are no longer fully bearing on the pile cap should be repaired. Partial bearing under full load could cause excessive crushing of the pile head or pile cap timber.

The north end of the pile caps at Bents 120, 119 and 121 should be repaired to provide support for the stringers and decking.

The batter pile connection chocks at Bents 122 and 118 have displaced and must be refastened to provide a suitable batter pile connection.

The deck stringers over the batter piles at Bent 118 are crushed and torn and can no longer support the imposed rail loads. These stringers must be replaced.

3.4 RECOMMENDATIONS

Repair recommendations are illustrated on Figure 7.

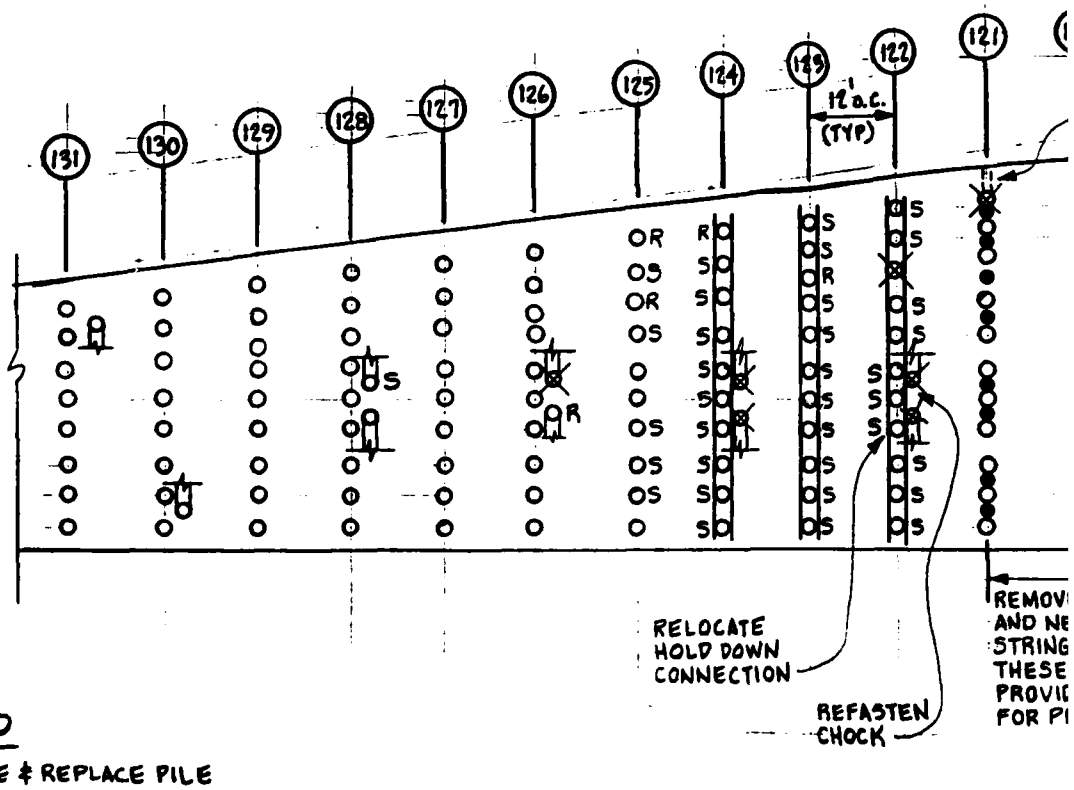
In Bents 119 and 120 it is recommended that nine new vertical piles be driven in each bent adjacent to the existing piles. In Bent 121, one new pile should be driven to replace the damaged pile (Pile H) and eight new vertical piles be driven adjacent to the existing piles. These new piles will strengthen these bents such that they can handle the design loads. A typical pile installation technique is illustrated in Figure 8.

Bracing should be installed, (see Figure 9), on Bents 118, 117, 122, 123 and 124. The bracing will reduce the effects of the permanent pile deflection by reducing the exposed length of the piles and altering the end conditions. Pile K in Bent 122 should be replaced with a new treated pile before the new bracing is installed.

Batter piles which have tension connection failures, Pile 2 Bent 116, Pile 4 Bents 120, 122, 124 and 126, should be replaced with new treated piles and refastened. Batter piles which have suffered compression failure, Pile 5 Bents 122 and 124, should be replaced with new treated piles.

Where the batter pile connection chocks have been displaced, Bents 118 and 122, the chocks should be re-positioned and re-fastened.

The loss of bearing on many of the effected vertical and batter piles should be corrected by installing hardwood shims (see Figure 10).

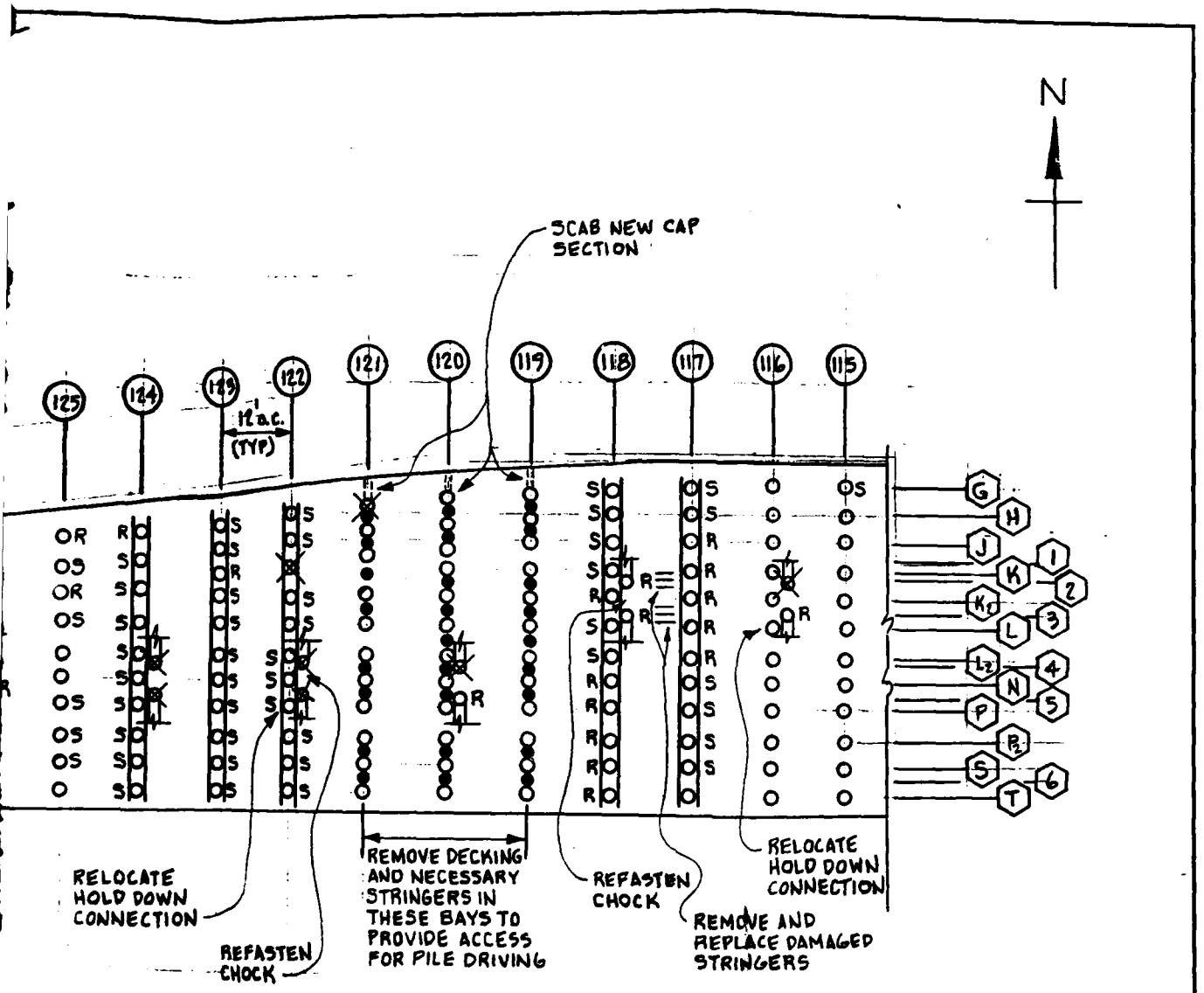


LEGEND

- ⊗ REMOVE & REPLACE PILE
- ● NEW PILE
- ⊙⊙ NEW BRACING
- S-SHIM
- R-RELOCATE HEAD SHIM & REFASTEN

PLAN

SCALE AS SHOWN



PLAN

SCALE AS SHOWN

2

GRAPHIC SCALE

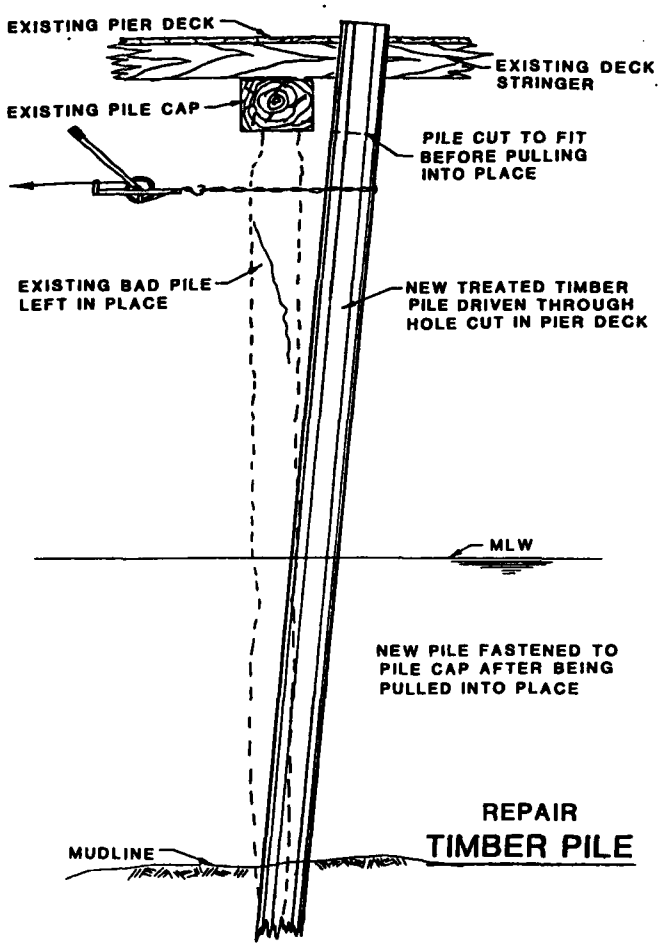
10' 0 10' 20' 30'

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.

NAVAL WEAPONS STATION - CONCORD, CA

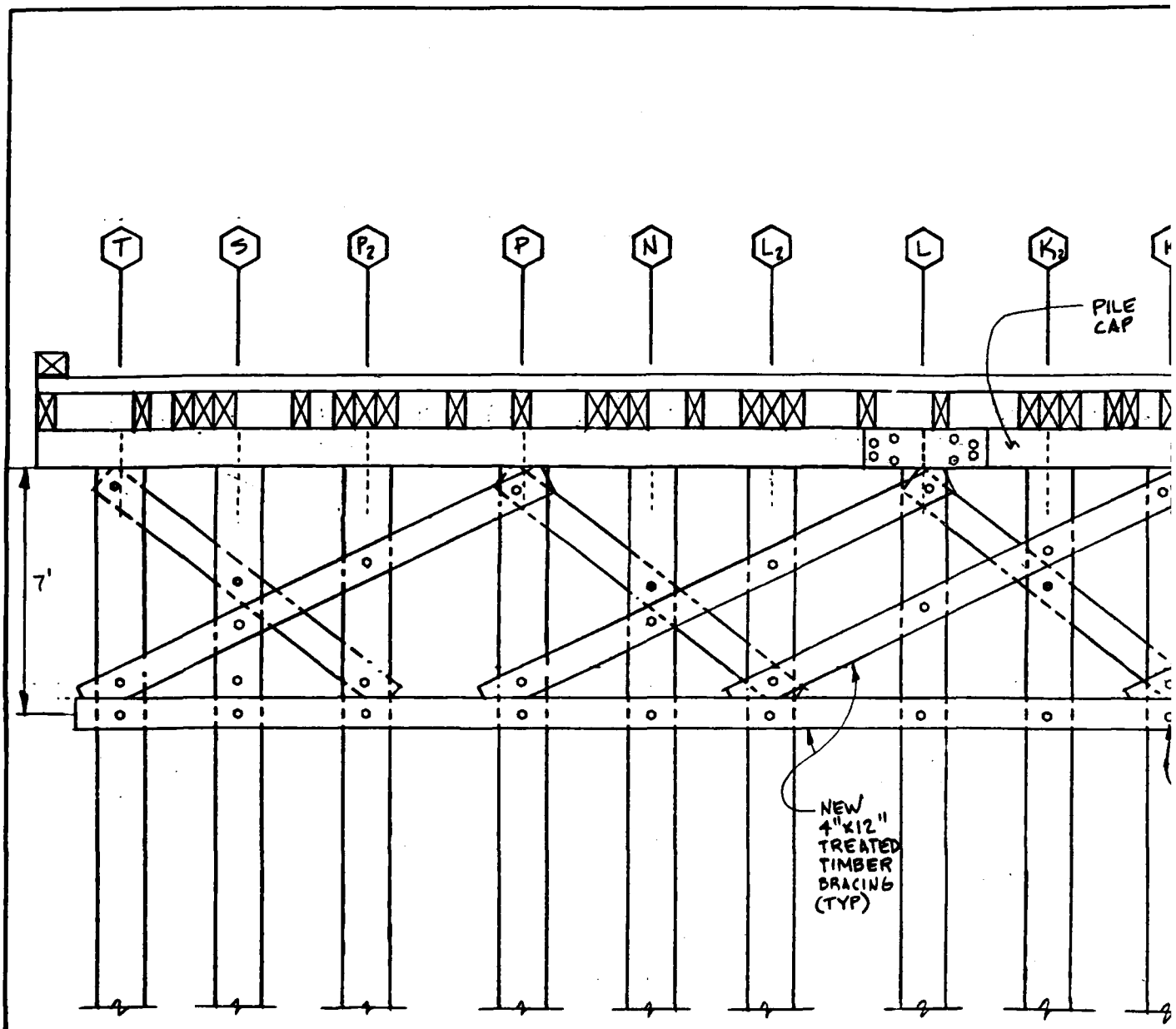
REPAIR PLAN

FIG. NO. 7



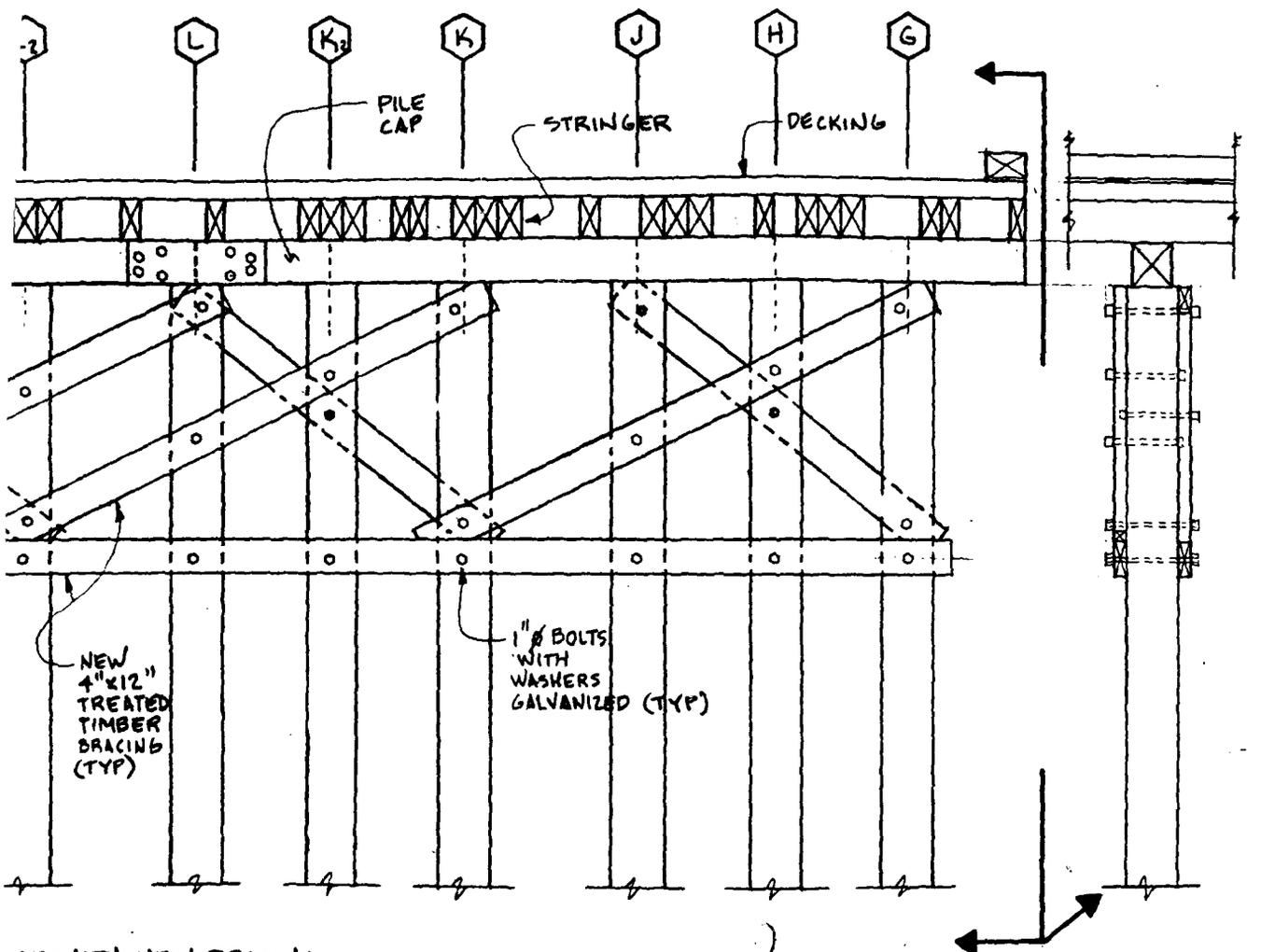
REPAIR
TIMBER PILE

GRAPHIC SCALE	CHILDS ENGINEERING CORPORATION BOX 555 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C
N/A		NAVAL WEAPONS STATION CONCORD, CA — PILE REPAIR — FIG.NO. 8



TYPICAL PILE BENT WITH NEW BRACING

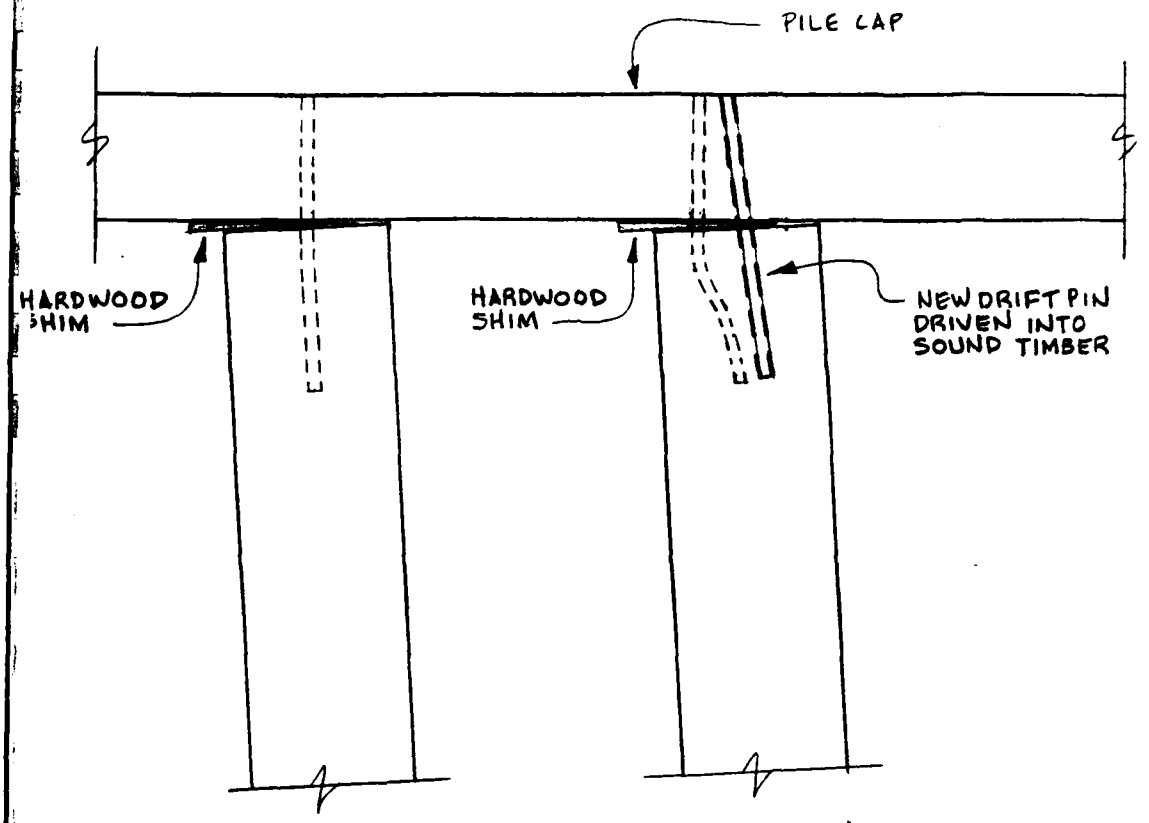
SCALE: 1/4" = 1'-0"



NT WITH NEW BRACING

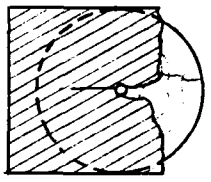
CALE: 1/4" = 1'-0"

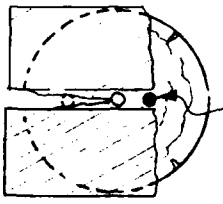
GRAPHIC SCALE	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.
1' 0 1' 2' 3' 4' 5' 6' 7'		NAVAL WEAPONS STATION CONCORD, CA — NEW BRACING — FIG NO 9



TYPICAL SHIM DETAIL

TYPICAL SHIM & FASTENER REPLACEMENT DETAIL





SECTION

SECTION

SCALE: $\frac{3}{4}$" = 1'-0"

GRAPHIC SCALE

1' 0 1' 2'

CHILDS ENGINEERING CORPORATION
BOX 333
MEDFIELD, MA

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.

NAVAL WEAPONS STATION CONCORD, CA

PILE REPAIR

FIG NO 10

The shims should be driven into the gaps and nailed in place to prevent slipping.

Where the pile to pile cap fastenings have bent or where local failure at the pile head or pile cap has occurred, new fastenings (drift pins) should be installed into sound timber.

At Bents 122 and 116 where the vertical pile tension connections have failed, the piles should be refastened. It is recommended that the connection pin be relocated 12" below and 90° from the existing connection location.

The damaged stringers at the batter pile connections in Bent 118 should be replaced.

The broken pile caps at Bents 120, 121 and 119 should be repaired by scabbing new sections of pile cap to the old caps.

When re-installing the trackage on the pier, care should be taken to insure that the rails are located over the main stringer groups. If necessary, new stringers should be added to support the rails.

The estimated cost of the proposed repairs is $153,000.00. A breakdown of the estimated cost can be found in the Appendix. (See Repair Summary Table on following page 3-18)

REPAIR SUMMARY TABLE

Item	Quantity
New Piles:	
Vertical -	28
Batter -	7
New Bracing:	5 Bents
Chock Refastening:	2 Bents
Shims:	48
Pile Refastening:	
Vertical -	14
Batter -	5
Vertical Pile Tension Connection Refastening:	2
Pile Cap Repair:	3 Bents
Stringer Repair:	2 Bays

APPENDIX

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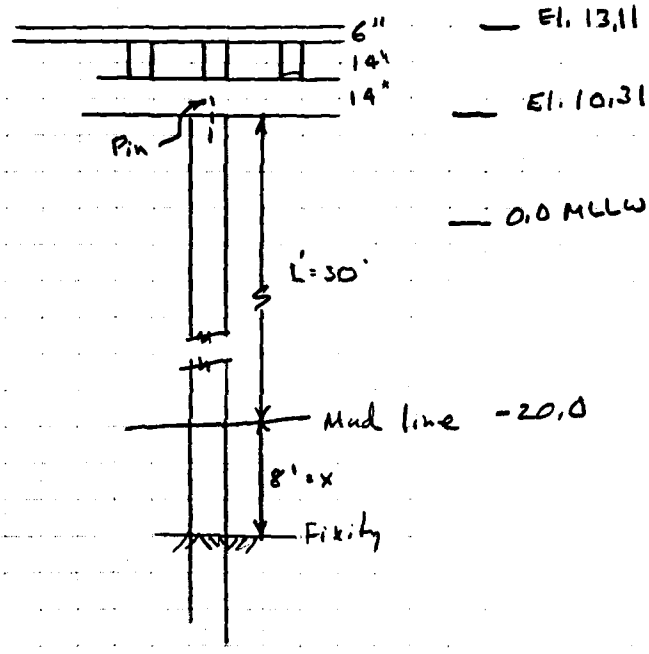
JOB Naval Weapons Station Goose Creek
SHEET NO 1 OF 2
CALCULATED BY DLP DATE 10/25/82
CHECKED BY CDS DATE 10/26/82
SCALE

Pier 4 -

Typical Pile: Per GFI - Loa 70' Butt 16"Ø (ave) Tip 8"Ø (ave) Driven Capacity 27 tons (ave)



Max. residual deflection @ bent 120, 12".

"Timber Const. Manual", Forest Products Lab., War Dept.

Column capacity -

(Euler) w/ F.S. of 3 $R = .274\,AE/(l/d)^2$

l = (for pin end)
= 4/3 (L'+x')
= 3/3 (38') = 25.6'
= 306"

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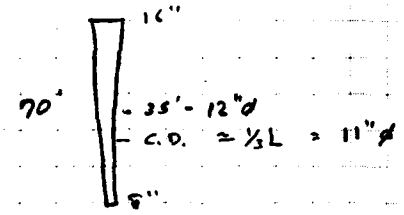
d = least dimension of sq. col. having same area as round col. @ critical diameter



$d = \sqrt{\frac{(11)^2\pi}{4}} = 9.75"$ $\quad A_{eco} = \frac{(10^2\pi}{4} = 95\ \#$

Assume
E = 1,500,000 psi (good fir) $\quad F_b = 1600$ psi
$F_c = 1000$ psi

(Euler) $\therefore R = \frac{.294\ (95)\ 1500000}{(306/9.75)^2} = 39,639\# = 19.8$ tons < 27 tons design capacity.

(Timber Const Manual) $\quad F_c' = \frac{3.619 E}{(l/r)^2} =$

$r = d/4 = 9/4 = 2.75"$

$F_c' = \frac{3.619\ (1500000)}{(306/2.75)^2} = 438$ psi

$I_{eo} = .049082\ d^4 = 718\ in^4$

$R = PA = 95(438) = 41,610\# = 20.8$ tons < 27 tons design capacity.

$S_{eo} = .098175\ d^3 = 131\ in^3$

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JOB
SHEET NO 3 OF 7
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Determine effects of deflection for pile capacity with combined stress.

$$\Delta_{max} = \frac{PL^3}{3EI}$$

$$12'' = \frac{PL^3}{3EI}$$

$$P = \frac{12''(1500000)\,3\,(718)}{(456)^3} = 408^{\#}$$

$$M = PL = 408^{\#}(456') = 186{,}048\ ''\text{-}\#$$

$$f_b = \frac{M}{S} = 186{,}048/131 = 1420\ psi$$

w/ $\ell/d = 306''/9.75'' = 31.4$ and $\sqrt{\frac{0.30(1500000)}{1000}} = 21.2$

Combined stress:

$$\frac{M'/S}{F_b - P/A} + \frac{P/A}{F'_c} \leq 1$$

P per pile assuming no dead load in lieu of duration factor - From DM-25,
Ammo piece train rail load = 2.2^{k}/ft/rail

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SHEET NO. 4 OF 7
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$P = [7.2^{k}/_{ft/rail}(12') \times 8\ rails]/_{12\ piles} = 57.6^{k}/pile = 28.8\ ton/pile$

Exceeds original design - check pile loads based on 600 psf (DM-25) Ammo pier deck load.

$P = [50' \times 12'] \times .6^{k}/_{12} = 30^{k}/pile = 15\ ton/pile$

Seems like a more reasonable design load.

$P/A = 20000^{\#}/_{95in^2} = 315\ psi$

$$\frac{M/S}{F_b - P/A} + \frac{P/A}{F_c'} \leq 1$$

$$\frac{1420}{1500 - 315} + \frac{315}{1438} = 1.20 + .22 = 1.42 > 1$$

Combine stress exceeds allowable.

Bents 120, 121 & 119 will require added piles

Check combined stress where permanent Δ is 6".

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JOB
SHEET NO 5 OF 7
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$\Delta_{max} = \frac{PL}{3EI}$

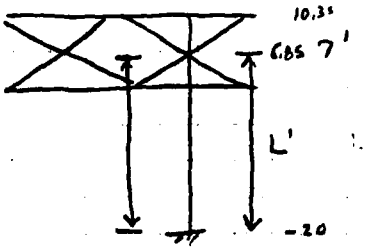
$P = \frac{6(1500000)\,3(718)}{(456)^2} = 204^{\#}$

$M = 93{,}024^{in\text{-}\#}$

$f_b = M/S = 710\ psi$

$$\frac{M/S}{F_b - P/A} + \frac{P/A}{F'_c} = \frac{710}{1500 - 315} + \frac{315}{438} = .60 + .72 = 1.32 > 1$$

Still over stressed - Brace pile bents -



$l = \frac{1}{2} L' = \frac{1}{2}(6.83 + 20 + 8)$
$= \frac{1}{2}(34.83) = 17.425$
$= 209''$

$F'_c = \frac{3.619\,(1500000)}{(209/9.75)^2} = 940\ psi$

Check max $l/d = 209/9.75 = 21.4 \approx 21.2$

use combined stress formula:

$$\frac{M/S}{F_b} + \frac{P/A}{F'_c} \leq 1$$

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SHEET NO 6 OF 7
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$\frac{710\ psi}{1500\ psi} + \frac{315\ psi}{940\ psi} = .47 + .34 = .81 < 1$

O.K.

Suggest bracing for bents 123, 122, 1118 and 117

Check combined stress for residual deflection of < 3"

$P = 408/4 = 102^{\#}$

$M = 102(456) = 46512^{"-\#}$

$f_b = M/S = 355\ psi$

Combined stress -

$$\frac{\frac{M}{S}}{F_b \cdot P/A} + \frac{P/A}{F'c} \leq$$

$\frac{355}{1500 - 315} + \frac{315}{438} = .30 + .72 = 1.02 \approx 1$ O.K.

No bracing needed on other bents.

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JOB
SHEET NO 7 OF 7
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Check bents 120, 121 and 119 for. No. of extra piles required:

Total load per bent - 360^K

Assume max (Euler) capacity of 40^K

New piles required without bracing = 9 piles

New piles required with brace -

$$R_{1\,pile} = \frac{.274\,(95)\,1500000}{(209"/9.75)^2} = 84972^{\#} = 42^t$$

42^t exceeds reasonable driven capacity of 27^t.

Max capacity with brace is 54^k

New piles needed with bracing

$360/54 = 7$ piles -

By inspection - cheaper to drive 9 piles than 7 piles plus bracing.

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JOB 498 - 82 Concord Calif.
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Cost Estimate: West Coast U.S. - Civilian Contractor

New pile - 70' Loa - in place, cut-off, fastened.

Vertical - $20/LF (treated) x 70' = $1400

Batter - $22/LF (treated) x 70' = $1540

Deck removal - $2/s.f.

Stringer removal - $2/L.f.

Refasten piles -

Vertical - $200/pile

Batter - $500/pile

Shim piles - $50/pile (hardwood, no treatment)

Bracing - treated timber - in-place including trim and hardware

$4.00/bf

Stringer and deck replacement - treated timber - in-place including trim and hardware

$4.00/bf

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JOB
SHEET NO 2 OF
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Based on recommendations:

Mobilization - Demobilization $10,000

New piles - 35

Vertical 28 @ $1400 $39,200

Batter 7 @ $1540 $10,780

Deck + stringer removal to access new pile driving -

Deck 12'x3' + 12'x3' + 12'x3' + 12'x3' + 12'x3' + 12'x3' + 24'x50' = 216 sf + 1200 sf = 1416 sf @ $2.00 = $2,832

stringer (3x12') 6 + 20 (24') = 216 lf + 480 lf = 696 lf @ $2.00 = $1,392

Deck + Stringer Replacement

Deck : 1416 sf @ 6 bf/sf = 8496 bf @ $4/bf = $33,984

Stringer : 696 lf @ 4.7 bf/sf = 3272 bf @ $4/bf = $13,088

Bracing - 212 lf of 4x12 per bent

5 bents @ 212 = 1060 l.f. @ 4 bf/lf = 4240 bf @ $4/bf = $16,960

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JOB
SHEET NO 3 OF
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Pile Shims -	48 piles @ $50/pile	$2,400
Refasten Piles -		
	Batter - 5 @ $500/pile	$2,500
	Vertical - 14 @ $200/pile	$2,800
Check refastening	LS	$800
Pile Hold down conn. refasten	LS	$500
Pile cap extension w/scabs	LS	$1,500
	Total	$138,736
	Contingencies (10%)	$14,000
	Budget	$153,000.00

END

DATE
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